THE STAR

FLOOD IMPACT ASSESMENT

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31.01.2018	A	35	Final	Eirian Crabbe	Stephen Brain	

1 EXECUTIVE SUMMARY

TTW has been appointed by The Star Entertainment Group Limited (SEGL), to complete a flood impact assessment for the proposed development of The Star, 20-80 Pyrmont Street, Pyrmont. This report only refers to the wider flooding behaviour of the catchment outside the extent of the development site. A separate report by Umow Lai provides information on stormwater within the development site.

The findings within this report are based on the flood model provided by City of Sydney Council and have been assessed against all relevant standards/guidelines, including the following:

- Darling Harbour Catchment Flood Study, BMT WBM, October 2014.
- City of Sydney Interim Floodplain Management Policy, Approved May 2014.
- Sydney Local Environmental Plan 2012.
- Sydney Development Control Plan, December 2013.
- Sydney Streets Technical Specifications, June 2016.
- NSW Floodplain Development Manual, 2005
- NSW Sea Level Rise Policy Statement (DECCW, 2009)
- NSW Floodplain Risk Management Guideline - Practical Consideration of Climate Change (DECCW, 2007
- SEARs

This flood impact assessment confirms that overland flows occur around the site and are generally contained within the road network. To mitigate flood hazard and flood risk, upgrades are proposed to the existing stormwater pits and pipes as detailed in Appendix B of this report. The proposed mitigation works reduce the 100-year ARI flood depth; reducing flood risk to the development, adjacent properties and the general public.

1.1 FLOOD BEHAVIOUR

The existing Council flood model results confirm that overland flows occur around the development site and are generally contained within the road network. Overland flow has the potential to overtop the kerb and flood the development site at the following locations:

- Trapped low point on Pyrmont Street with no overland flow route.
- Low point on Edward Street, within light rail track, with an overland flow route to Pirrama Road.
- Low point in Pirrama Road, east of Edward Street, with an overland flow route to Darling Harbour.
- Low point in Pirrama Road, north west of Edward Street, with an overland flow route to Darling Harbour.

The existing Council flood model results show significant flood depth at these low points. Conservative pit blockage factors are the primary reason for these high depths, with a blockage factor of 100% used for all sag pits. This assumes that no surface water runoff is able to flow into the storm water system at low points, regardless of the capacity of the pit inlet or pipes. The Darling Harbour flood study confirms that there is no recorded historical flooding at the development site (from newspaper articles and Sydney Water records), and the existing Council flood model has been amended to use the pit blockage factors stated in Council's development policy; *Sydney Streets Technical Specifications.*

The trapped low point on Pyrmont Street is a critical location as water ponding here would not be able to escape, and has the potential to flood the development site through building entrances. A proposed vehicle entrance to the existing basement car park is located near the low point on Pyrmont Street and may be at risk of flooding. An existing vehicle entrance to the basement car park is located near the low point on Edward Street and is also at risk of flooding. The existing exit from the basement to the north of Jones Bay Road is not flood affected.

1.2 FLOOD MITIGATION

To mitigate and reduce the flood risk to the development site, it is proposed that upgrades are made to provide additional capacity to the existing storm water pit inlets and pipes (refer to Table 1). Alternative options were considered and disregarded as they did not provide a significant benefit in flood reduction and had high associated costs.

Pyrmont Street	Edward Street
16 existing pits upgraded to 3m kerb inlet pits	2 new and 2 existing kerb inlet pits upgraded to 3m
36m of 375mm pipe upgraded to 600mm pipe	5m of new 750mm pipe
68m of 450mm pipe upgraded to 900mm pipe	9m of 300mm pipe upgraded to 600mm pipe
	3m of 375mm pipe upgraded to 750mm pipe
	10m of new 600mm pipe

Table 1. Proposed Stormwater Mitigation Works

The proposed mitigation works reduce the 100 year ARI flood depth from 420mm to 230mm at the low point in Pyrmont Street, and from 390mm to 290mm at the low point in Edward Street. The lower flood levels not only reduce flood risk to the development, but they also reduce flood risk to existing adjacent properties and the general public.

1.3 CLIMATE CHANGE

Climate change has the potential to impact flooding through increased sea level and rainfall intensities. Allowances have been made within the proposed flood model for climate change, in accordance with the parameters adopted in the Council flood model and current Council guidance.

The flood model results show that there is a negligible impact on flood levels as a result of sea level rise. The flood model results also show that the potential impacts of increased rainfall is not significant and does not increase flood risk to the development site. The proposed stormwater mitigation measures provide a much greater reduction in flood level than the possible increase in flood level from climate change.

1.4 FLOOD PLANNING LEVELS

The flood levels vary around the development site level due to the existing varying topography.

For non-critical areas the flood levels around the development site can be taken as 'top of kerb' for the 100 year ARI and 'top of kerb +100mm' for the PMF.

For critical areas, adjacent to the low points in the road network, flood levels around the development site can be taken as the maximum of 'top of kerb' or specific flood level for the 100 year ARI and the maximum of 'top of kerb +100mm' or specific flood level for the PMF (refer to Table 2).

Critical Flood Areas	100 Year ARI Flood Level	PMF Level
Low point in Pyrmont Street	Max of 6.51m / Top of Kerb	Max of 6.60m / Top of Kerb + 100mm*
Low point in Edward Street	Max of 2.67m / Top of Kerb	Max of 2.89m / Top of Kerb + 100mm*
Low point in Pirrama Road NW of Edward St	Max of 2.63m / Top of Kerb	Max of 2.70m / Top of Kerb + 100mm*
Non-Critical Flood Areas	Top of Kerb	Top of Kerb + 100mm*

Table 2. 100 Year ARI And PMF Flood Levels

The Flood Planning Levels for the different proposed development uses are shown in Table 3 and are in accordance with the *Interim Floodplain Management Policy*.

Proposed Development Use	Flood Planning Level
Residential Habitable Floor Level	100 year ARI flood level +0.5m
Residential Non-Habitable Floor Level	100 year ARI flood level
Retail and Business Floor Level	100 year ARI flood level
Below Ground Parking*	100 year ARI flood level +0.5m
Critical Facilities Floor Level	100 year ARI flood level +0.5m
Access to and from critical facility within development site	100 year ARI flood level

Note* The below ground garage/car park level applies to all possible ingress points to the car park such as vehicle entrances and exits, ventilation ducts, windows, light wells, lift shaft openings, risers and stairwells.

Table 3. Flood Planning Levels

In accordance with City of Sydney DCP, protection must be provided to the proposed vehicle entrance on Pyrmont Street up the 100 year ARI flood level +0.5m. This protection can be achieved with a flood gate across the full vehicle entrance opening to a height of 7.44m AHD.

For future design stages of the development, any changes to the proposed stormwater mitigation outlined in this report will require further flood modelling and a summary report confirming the results.

2 INTRODUCTION

SEGL has commenced a five-year redevelopment journey to create a landmark, exemplar integrated resort. This proposed redevelopment will occur through the lodgement of two s75W modification applications to the original Major Project Approval (MP08_0098) with the Department of Planning and Environment (the Department).

Modification 14 (Mod 14) was determined in October 2017 and included approval for a range of upgrades to the existing site. These upgrades included the enclosure of the level 3 terrace to facilitate an expansion in gaming floor area and a new bar and restaurants, expansion of the level 3 pre-function space, changes to the Astral Hotel lobby and retail space, and alterations to internal vertical transportation, services and infrastructure, including the harbour heat rejection system.

Modification 13 (Mod 13) is a modification to the development as approved under MP08_0098, up to and including Mod 14. Mod 13 proposes the development of a new Ritz-Carlton Hotel and Residential Tower in the northern portion of the site with associated podium treatment, as well as other transport, retail, food and beverage improvements across the site. It is Modification 13 that is the subject of this report. A full description of the proposals is included in Appendix A.

2.1 SITE LOCATION AND DESCRIPTION

The subject site (the site) is located at 20-80 Pyrmont Street, Pyrmont, which is legally described as Lot 500 in DP1161507, Lot 301 in DP 873212 (SP56913), and Lot 302 in DP873212. The site also accommodates a light rail line (including 'The Star' light rail station) legally described as Lot 211 in DP 870336. The service road to the north of the site, comprising Lot 1 in DP 867854 and Lot 201 in DP 867855, is also part of the proposal under Modification 13.

The site is bounded by Pirrama Road to the north-east, Jones Bay Road to the north-west, Pyrmont Street to the south-west, Union Street to the south and Edward Street to the east. The location and configuration of the site is shown in Figure 1 below.

The site is leased by SEGL from the Independent Liquor and Gaming Authority (ILGA). SEGL is a leading operator of integrated resorts that appeal to both local and international visitors. SEGL is the operator of The Star Sydney (The Star), with a casino licence to operate a casino through to the year 2093.

The site has a total area of 39,206 m^2 (excluding Lot 1 in DP 867854 and Lot 201 in DP 867855 to the north), and is occupied by the existing integrated resort which includes a multi-storey entertainment facility, gaming areas, retail spaces, multiple restaurants and bars, the Sydney Lyric Theatre, 480 hotel rooms/serviced apartments across three towers, and basement parking.

Figure 1. Aerial Image of The Subject Site (base map source: maps.six.nsw.gov.au)

2.2 LEGAL DESCRIPTION AND OWNERSHIP

The site comprises the following lots as shown in Table 4 and Figure 2 below.

Details	Uses	Ownership
Lot 211 in DP 870336	The Light Rail Corridor	Owned by Rail Corporation New South Wales
Lot 500 in DP 1161507	The Star site	Owned by the Casino Control Authority, leased by SEGL
Lot 301 in DP 873212	Astral Hotel	Owned by the Casino Control Authority, leased by SEGL
Lot 302 in DP 873212	Astral Residences divided into strata (Strata Plan - SP 56913);	Stratum owned by the Casino Control Authority, leased by SEGL
Lot 1 in DP 867854	Service road	Owned by the Casino Control Authority, leased by SEGL
Lot 201 in DP 867855	Service road	Owned by the Casino Control Authority, leased by SEGL

Table 4. Legal Description and Ownership

Figure 2. Legal Description of The Site (base map source: maps.six.nsw.gov.au)

2.3 TOPOGRAPHY

The developed site generally falls north east toward Darling Harbour, with a maximum level difference of around 9.0m between Pyrmont Street and Pirrama Road. Figure 3 shows levels around the site, fall directions and low points. There are four sag points within the road network as follows:

- Trapped low point on Pyrmont Street with no overland flow route.
- Low point on Edward Street, within light rail track, with an overland flow route to Pirrama Road.
- Low point in Pirrama Road, east of Edward Street, with an overland flow route north west along Pirrama Road and to Darling Harbour.
- Low point in Pirrama Road, east of north west of Edward Street, with an overland flow route to Darling Harbour.

The sag point in Pyrmont Street is critical as water ponding at this location would not be able to escape and could flood the development site, through building entrances. The other sag points are not as critical as ponding water would overflow towards Darling Harbour.

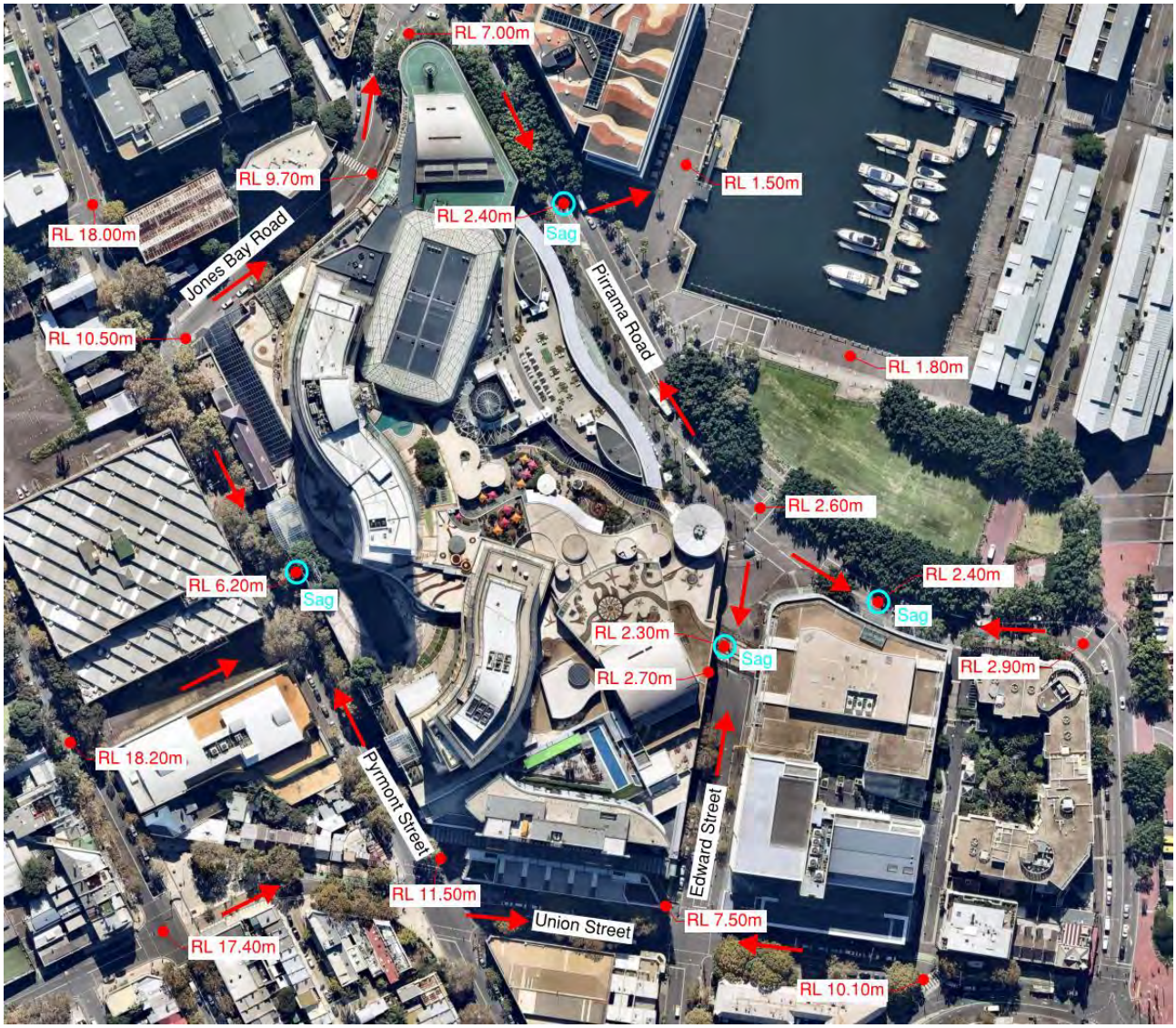


Figure 3. Site Topography

2.4 PROPOSED DEVELOPMENT

The proposed redevelopment of the site includes a number of modifications, additions and reconfigurations to the existing structures and facilities within the site. All proposed works are within the development site and will not have an impact on the wider catchment flood behaviour. The only area of development that will have an impact on flood risk is a new vehicle entrance to the existing below ground car park on Pyrmont Street. An image of the existing and proposed structure at the location of the new entrance is shown in figure 4 and 5 respectively. Proposed development layout plans are included in Appendix A along with a full description of the development proposals.

Existing vehicle entrances on Pyrmont Street and Edward Street are potentially at risk of flooding from overland flow. The existing vehicle exit from the basement carpark to Pirrama Road to the north of Jones Bay Road is not within an overland flood route and is not flood affected.

Figure 4. Existing structure on Pyrmont Street

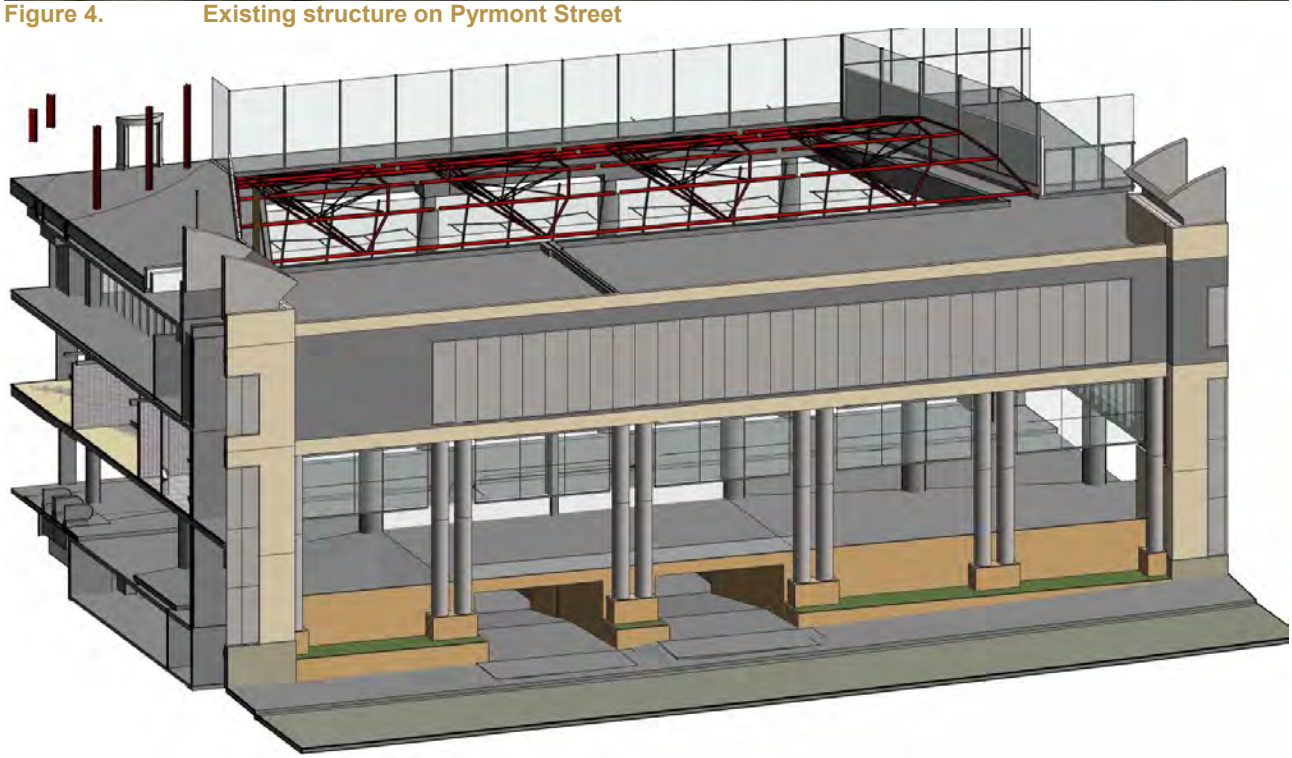


Figure 5. 3D model of proposed new vehicle entrance on Pyrmont Street

3 EXISTING FLOODING

3.1 CATCHMENT AND EXISTING STORMWATER NETWORK

The development site is located within the Darling Harbour catchment. This catchment lies wholly within the City of Sydney LGA, and is approximately 307ha. The catchment is fully urbanised consisting of high density housing and commercial development. There are no natural or open watercourses within the catchment, instead storm water flows are conveyed to Sydney Harbour via Sydney Water's main trunk drainage system. This large trunk system is connected to Council's minor storm water drainage system which includes covered pipes, culverts and pit inlet structures.

The existing storm water network around the site consists of a large rectangular culvert that runs along Pyrmont Street, Jones bay Road and Pirrama Road, before discharging into Darling Harbour (refer to figure 6 and Appendix B). Another large trunk system runs from the light rail track in Edward Street across Pirrama road and into Darling Harbour. A number of minor networks exist that either discharge into the main trunk system or directly into Darling Harbour.

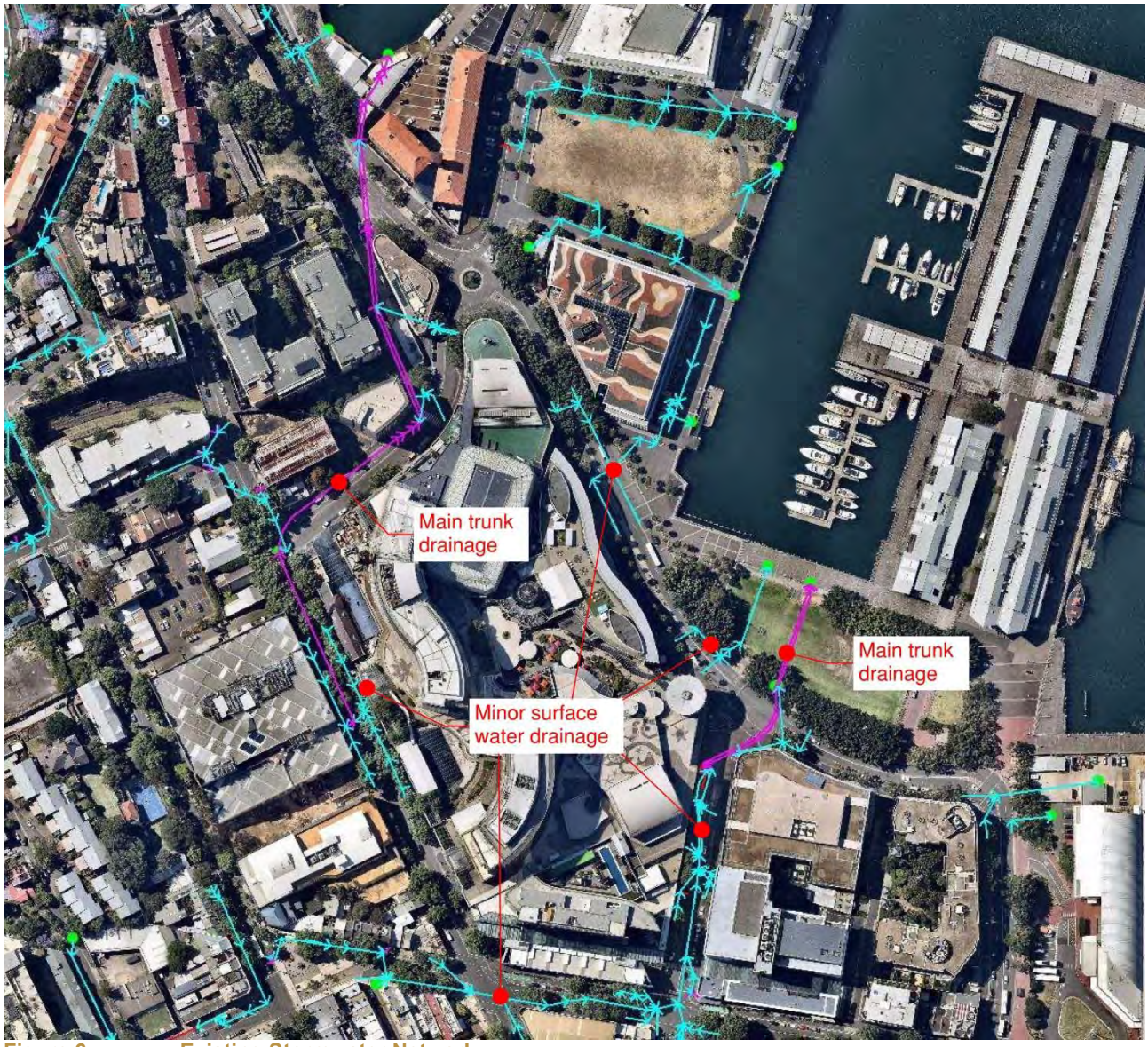


Figure 6. Existing Stormwater Network

3.2 EXISTING FLOOD MODEL

Council has completed a flood study for the Darling Harbour Catchment which also incorporates a number of previous studies and reports; *Darling Harbour Catchment Flood Study, BMT WBM, October 2014*. This comprehensive study includes an integrated 1d/2d flood model that simulates the catchment hydrology, together with the hydraulic drainage networks flows and overland flows. The model was calibrated and verified and generally provides a good representation of observed flood behaviour across the catchment, compared to historical information. The report confirms that there is no recorded historical flooding at the development site (from newspaper articles and Sydney Water records).

Council has provided the flood model to compare different options and scenarios following the proposed development. The 100 year ARI results of the model show that flooding is most likely to occur at the low points of the road network. Flood levels, depths and hazard (a product of flood velocity and depth) vary around the development site due to the local topography. The model confirms that vehicle entrances to the existing basement on Pyrmont Street and Edward Street are at risk of flooding. The exit from the existing basement north of Jones Bay Road is not at risk of flooding. The existing 100 year ARI flood model results are shown in Table 5 and figures 7 and 8.

Location	Flood Depth	Flood Hazard
Trapped low point in Pyrmont Street	1.21m	High
Low point in Light Rail Corridor, Edward Street	0.47m	Low
Low point in Pirrama Road, east of Edward Street	0.55m	Low
Low point in Pirrama Road, north west of Edward Street	0.47m	Low

Table 5. Council's 100 Year ARI Flood Model Results

Figure 7. Existing Council Model 100 Year ARI Flood Depth

Figure 8. Existing Council Model 100 Year ARI Flood Hazard

3.3 PIT BLOCKAGE FACTOR

The existing Council flood model shows significant flood water ponding at low points for the 100 year ARI flood. These low points are typically drained by kerb inlet pits that connect to underground storm drainage system. For all design events rarer than 5year ARI, the existing flood model assumes that sag pits have a blockage factor of 100% and on-grade pits (not at low points) have a blockage factor of 50%.

The blockage factors for the existing flood model assume that no surface runoff is able to flow into the storm water system at low points, regardless of the capacity of the pit inlet or pipes. This is the principle reason that the Council flood model results show excessive ponding at sag locations during the 100 year ARI. A secondary reason for ponding at low points is the capacity of the minor stormwater pipes and inlet pits, as discussed in section 3.4.

In comparison, the *City of Sydney Stormwater Drainage Design Code* states that kerb inlet pits less than 1m length have a blockage factor of 70% for sag pits and 50% for on-grade pits. For kerb inlet pits greater than 1m length a blockage factor of 50% for sag pits and 20% for on-grade pits applies. For grate only inlets a blockage factor of 90% applies for both sag and on-grade pits.

The development site has no recorded history of flooding and the pit blockage factors adopted in the Council flood model are very conservative for this site location. For the purposes of this assessment, the Council flood model has been amended to include the blockage factors set out in the *City of Sydney Design Code.* All existing kerb inlet pits are assumed to be less than 1m for blockage factor purposes. For proposed stormwater upgrades, new kerb inlet pits will be designed with an inlet length greater than 1m and the lower corresponding blockage factor has been applied. A comparison of the pit blockage factors is summarised in Table 6. Discussions with Council's Water Assets Senior Engineer confirm that the use of design code blockage factors is acceptable, refer to Appendix C for record of correspondence.

Pit Type	Existing Model	City of Sydney		Amended Model	
				Existing Pits	New Pits
Sag: kerb Inlet	100%	70% < 1m	50% > 1m	70%	50%
Sag: grate only	100%	90%	90%	90%	90%
On-grade: kerb Inlet	50%	50% < 1m	20% > 1m	50%	20%
On-grade: grate only	50%	90%	90%	90%	90%

Table 6. Pit Blockage Factors

3.4 EXISTING FLOODING WITH AMENDED PIT BLOCKAGE

The existing 100 year ARI flood model results with amended pit blockage factors show that flood water still ponds at low points within the road network. The flood depth and hazard is reduced at these low points, compared with the existing Council flood model, as overland flood water is able to enter the storm water system through the pit inlets. The amended 100 year ARI flood model results are shown in table 7 and figures 9 and 10.

Location	Council Model Flood Depth	Amended Model Flood Depth	Amended Model Flood Hazard
Trapped low point in Pyrmont Street	1.21m	0.42m	Low
Low point in Light Rail Corridor, Edward Street	0.47m	0.39m	Low
Low point in Pirrama Road, east of Edward Street	0.55m	0.46m	Low
Low point in Pirrama Road, NW of Edward Street	0.47m	0.43m	Low

Table 7. Existing 100 Year ARI Flood Model Results with Amended Pit Blockage factors

Figure 9. Existing 100 Year ARI Flood Depths With Amended Pit Blockage Factors

Figure 10. Existing 100 Year ARI Flood Hazard With Amended Pit Blockage Factors

The flood model results with amended pit blockage factors show that there is still a risk of flooding to the development site, particularly at the trapped low point in Pyrmont Street. There are a number of fire exit doors and vehicle entrances to the development site along Pyrmont Street. A detailed extract of the flood model results with the proposed and existing entrance locations is shown in Figure 11. The results show that the existing flood depth in Pyrmont Street is a maximum of 422mm that would overtop the road kerbs and flood the existing fire exit doors. The existing vehicle entrances are outside the flood water with a flood depth less than 100mm that would be contained within the road kerbs.

The amended flood model results show that there is also a risk of flooding to the development at the existing vehicle entrance on Edward Street. refer to figure 12. The depth of floodwater is 385mm in the light rail corridor and 229mm at the existing vehicle entrance.

Due to the existing flood risk, flood mitigation options were assessed to alleviate flood depths around the development. These mitigation measures and results are discussed in Section 4.

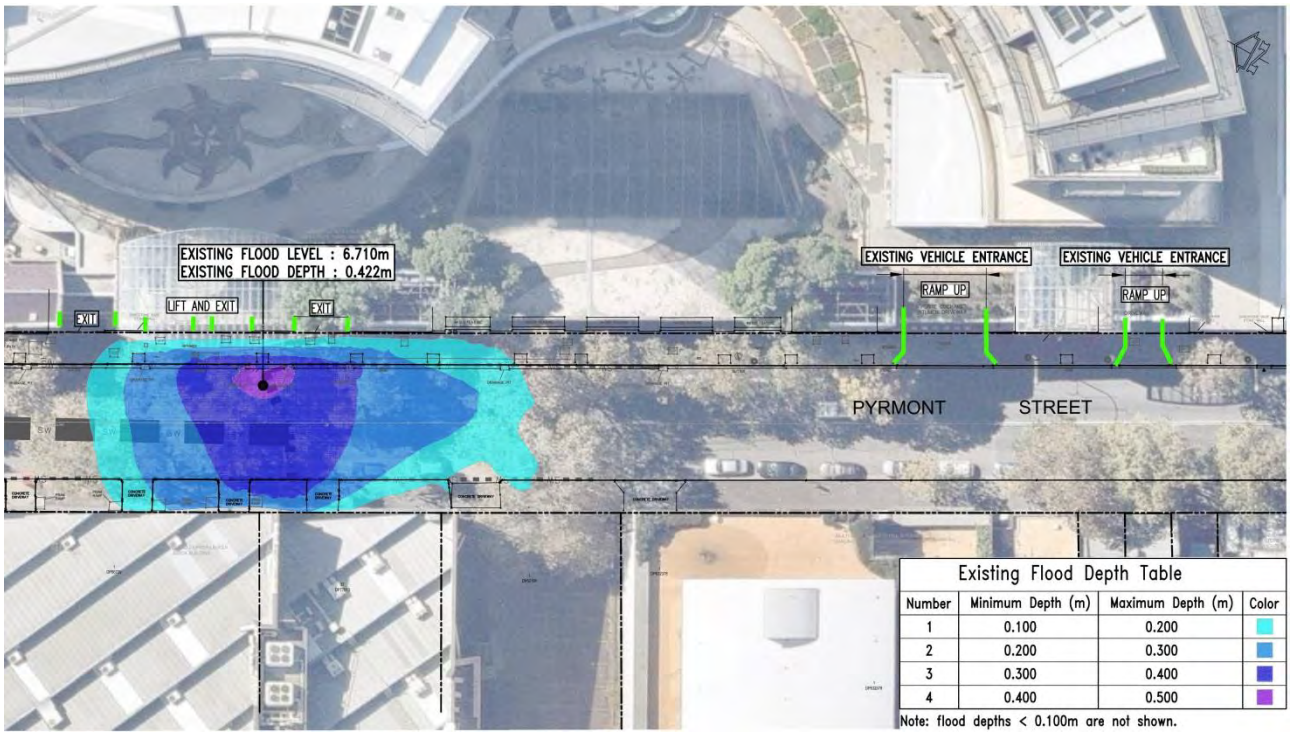


Figure 11. Existing 100 Year ARI Flood Depth on Pyrmont Street (flood depth<100mm not shown)

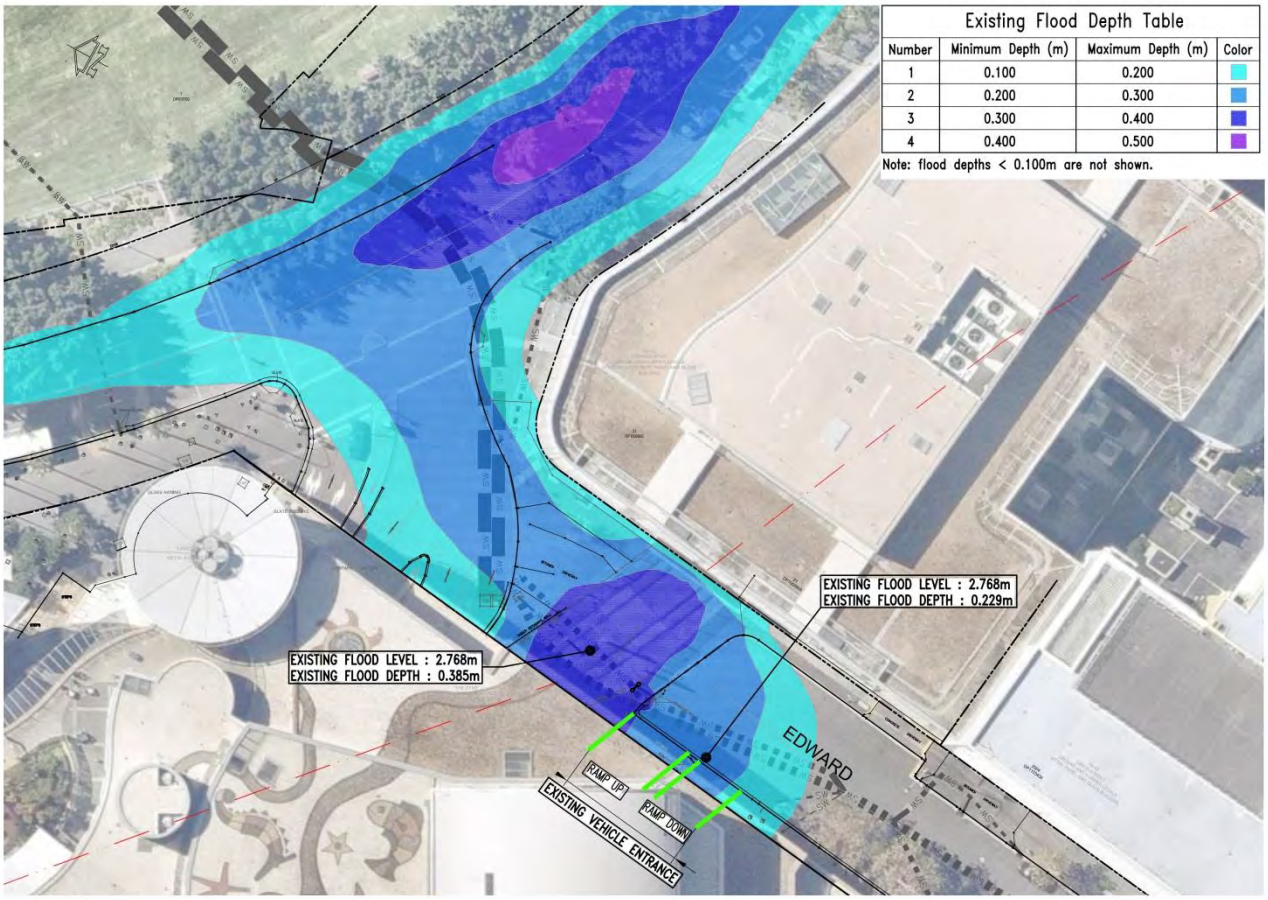


Figure 12. Existing 100 Year ARI Flood Depth on Edward Street (flood depth<100mm not shown)

4 PROPOSED FLOODING

4.1 PROPOSED STORMWATER WORKS ON PYRMONT STREET

To alleviate the flood depth at the low point in Pyrmont Street, a number of stormwater upgrades options were considered as follows:

1. Upgrading the main trunk drainage along Pyrmont Street
2. Upgrading the pits and pipes along Pyrmont Street
3. Providing a new 900mm diameter storm water pipe through the development site to Darling Harbour

Upgrading the main trunk drainage along Pyrmont Street would be a difficult and costly option, without providing a significant benefit to flood risk. The existing rectangular culvert is 2.55 wide by 1.88m high with an invert level around 4.40m deep at its upstream near the low point in Pyrmont Street, and around 11.30m deep at the junction with Jones Bay Road. Upgrades to the minor pit/pipe system have a much greater positive impact on flood levels than upgrades to the main trunk system and this option has been discounted.

The existing pits along Pyrmont Street are generally 1m kerb inlet pits which do not have a very large inlet capacity. Furthermore the pipe system connecting these pits to the main trunk culvert is between 375mm and 450mm diameter. To enable a greater volume of flood water to reach the main trunk culvert, an increase in the inlet and pipe capacity is required for the existing pits and pipes on both sides of Pyrmont Street, as follows (refer to figure 13 and Appendix C):

- 16 existing 1m kerb inlet pits upgraded to 3m kerb inlet pits.
- 36m of 375mm diameter pipe upgraded to 600mm diameter pipe
- 68m of 450mm pipe upgraded to 900mm diameter pipe

In addition to the stormwater upgrades above, an additional option was also considered for running a new 900mm diameter pipe through the basement of development site with a new outfall to Darling Harbour. The existing pits on the north east side of Pyrmont Street would connect to this new pipe instead of connecting to the existing main trunk culvert. This new pipe would be around 190m in length and would need to be routed through the existing basement car park and would have a negative impact on the existing car park spaces. There was no significant benefit in flood reduction in Pyrmont Street and this option has been discounted.

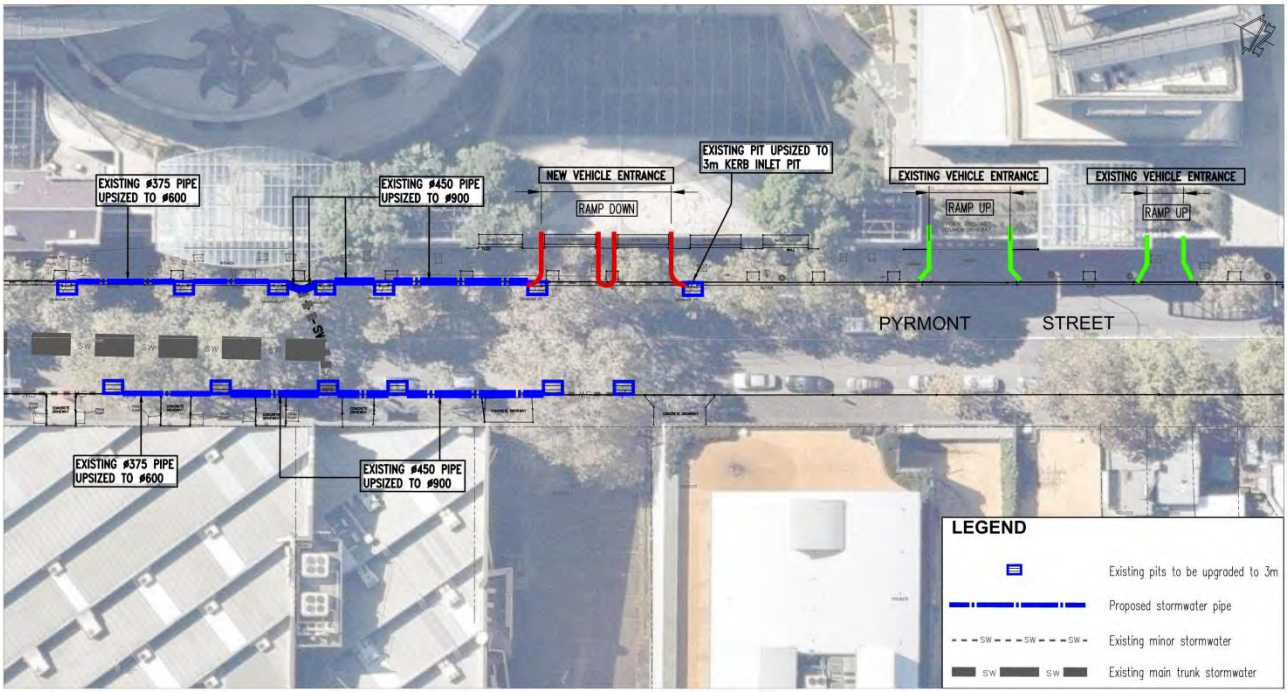


Figure 13. Proposed Stormwater Works On Pyrmont Street

4.2 PROPOSED STORMWATER WORKS ON EDWARD STREET

The low point, and greatest flood depth, along Edward Street occurs within the light rail corridor, however proposed works have only been considered outside the light rail corridor. To alleviate the flood depth in Edward Street, an increase in the inlet and pipe capacity is required for the existing pits and pipes in Edward Street. The proposed stormwater upgrades are as follows (refer to figure 14 and Appendix C):

- 2 existing 1.8m kerb inlet pits upsized to 3m kerb inlet pits
- 2 new 3m kerb inlet pits
- 9m of 300mm diameter pipe upgraded to 600mm diameter pipe
- 3m of 375mm pipe upgraded to 750mm diameter pipe
- 10m of new 600mm diameter pipe
- 5m of new 750mm diameter pipe

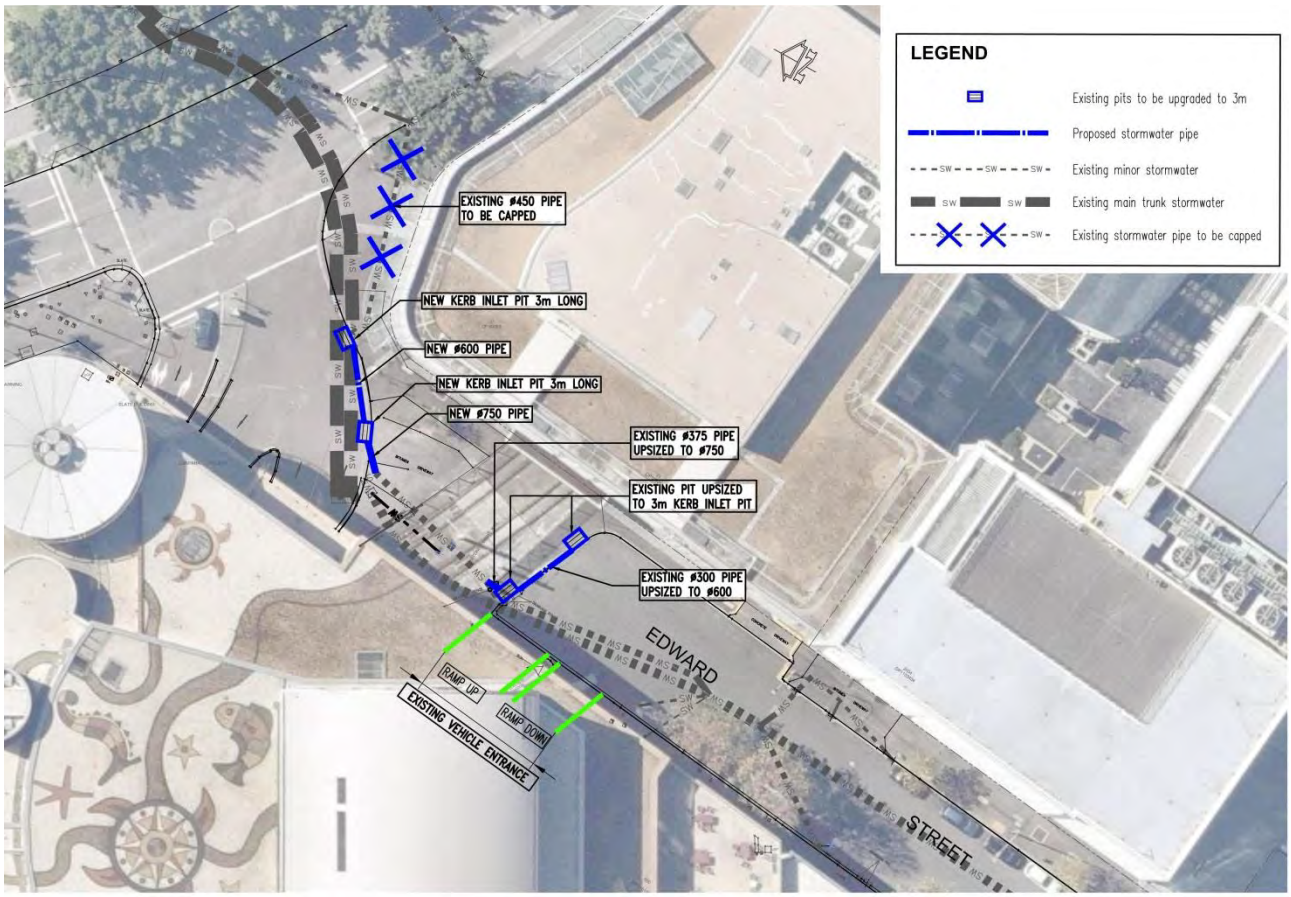


Figure 14. Proposed Stormwater Works On Edward Street

4.3 PROPOSED FLOODING WITH STORMWATER UPGRADES

The proposed 100 year ARI flood model results, which include the proposed stormwater upgrades, show that the depth of flooding is reduced at the low points in Pyrmont Street, Edward Street, and Pirrama road, east of Edward Street. The proposed 100 year ARI flood model results are shown in table 8 and figure 15.

Location	Council Model Flood Depth	Amended Model Flood Depth	Proposed Model Flood Depth
Trapped low point in Pyrmont Street	1.21m	0.42m	0.23m
Low point in Light Rail Corridor, Edward Street	0.47m	0.39m	0.29m
Low point in Pirrama Road, east of Edward Street	0.55m	0.46m	0.38m
Low point in Pirrama Road, NW of Edward Street	0.47m	0.43m	0.43m

Table 8. Proposed 100 Year ARI Flood Model Results With Stormwater Upgrades

Figure 15. Proposed 100 Year ARI Flood Model Results With Stormwater Upgrades

The proposed stormwater upgrades reduce the flooding in Pyrmont Street and Edward Street. The increased pit inlet and pipe capacities allow a greater volume of flood water to enter the main trunk stormwater culverts.

A detailed extract of the proposed flood model results for Pyrmont Street is shown in figure 16. The maximum flood depth at the low point of the road is 226mm, compared to 422mm without the stormwater upgrades. At the proposed vehicle entrance the flood depth in the road is 56mm compared with the existing depth of 143mm. With the proposed stormwater works, flood water would be contained within the road kerbs and would not reach the proposed vehicle ramp entrance. The existing vehicle entrances on Pyrmont Street remain flood free.

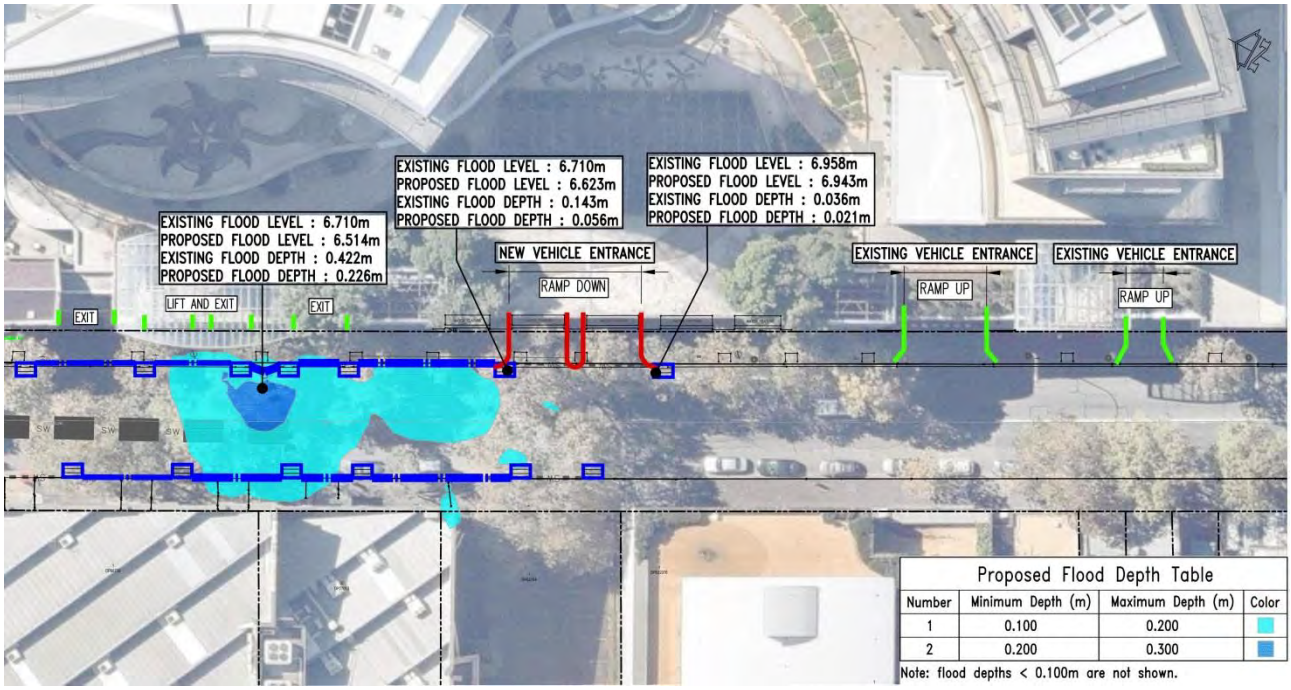


Figure 16. Proposed 100 Year ARI Flood Depth on Pyrmont Street (flood depth<100mm not shown)

A detailed extract of the proposed flood model results for Edward Street is shown in figure 17. The maximum flood depth at the low point within the light rail corridor is 285mm, compared to 385mm without the stormwater upgrades.

At the proposed vehicle entrance the flood depth in the road is 129mm compared with the existing depth of 229mm. The back of footpath level is typically around 170 – 200mm above the edge of road level (120-150mm high kerb with 50mm fall across a 2m footpath), and flood water would not reach the existing vehicle ramp entrance.

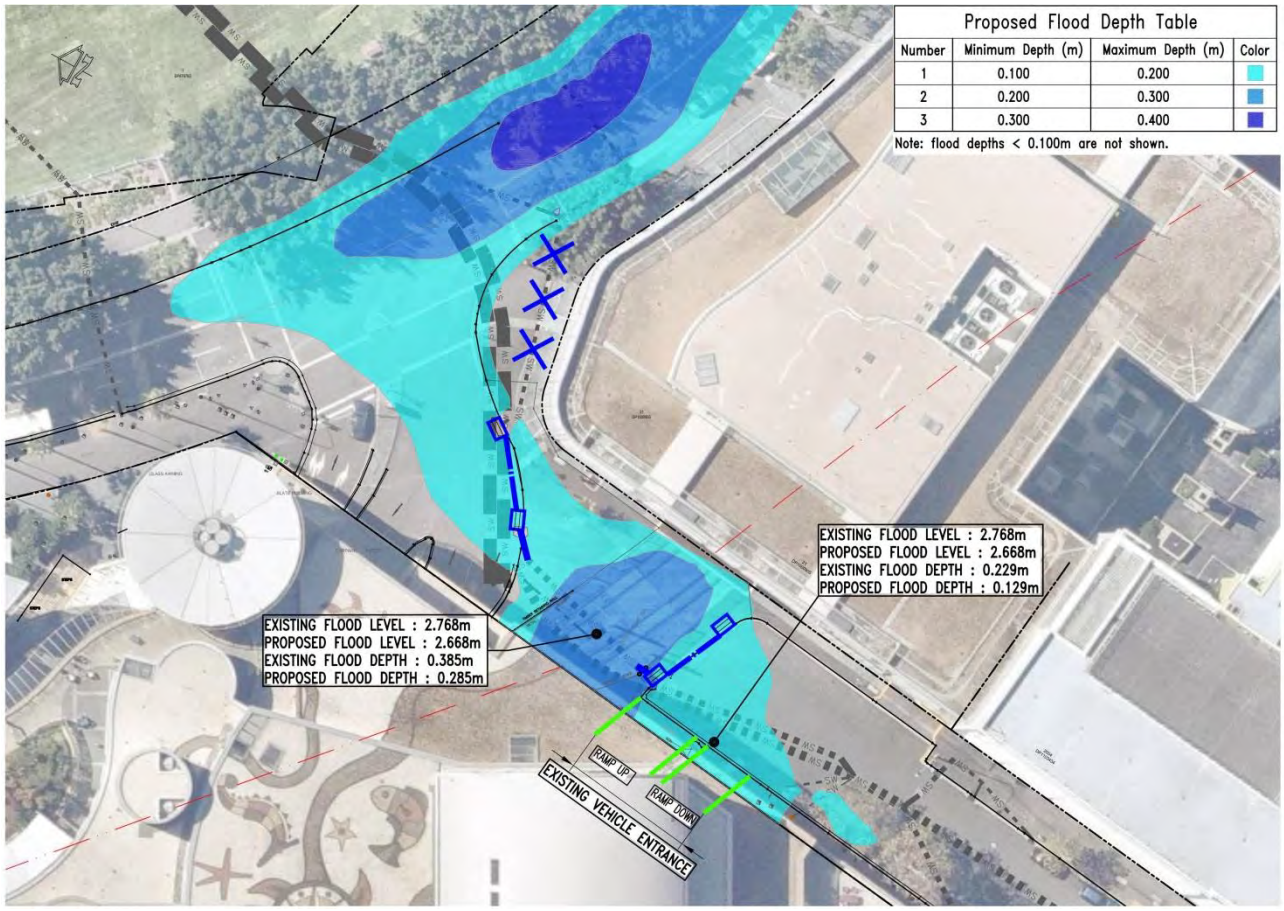


Figure 17. Proposed 100 Year ARI Flood Depth on Edward Street (flood depth<100mm not shown)

5 CLIMATE CHANGE

The existing Council flood model includes sensitivity analysis for the potential impacts of climate change. The main impacts on flooding as result of climate change are an increase in sea water level, and an increase in rainfall intensities. The increase in sea level adopted within the Council model is based on *NSW Sea Level Rise Policy Statement (DECCW, 2009*. The increase in rainfall intensities adopted within the Council model is based on *NSW Floodplain Risk Management Guideline - Practical Consideration of Climate Change (DECCW, 2007)*. The allowances that have been made for climate change area as follows:

- 0.9m increase in sea level by 2100 compared to the 1990 mean sea level.
- A range of +10% to +30% increase in rainfall intensities. The +10% increase scenario is the current best estimate for the Sydney Metropolitan region.

The existing Council model shows that there is negligible impact on flood level at the development site (between 0mm and 20mm increase) as a result from a 0.9m rise in sea levels. The existing model shows that there is an impact on flood levels as a result of increase in rainfall intensities. For the 100 year ARI flood with a 10% increase in rainfall intensity, the modelling shows an increase in flood depth of 100mm at the low point in Pyrmont Street, and 20mm at the low point in Edward Street.

The same climate change allowances were used for the proposed flood model, which include the proposed stormwater upgrades. Sea level rise had a negligible effect on flood levels at the development site consistent with the original Council model. The increase in flood depth associated with increased rainfall intensity for the critical flood locations around the development site are shown in Table 9 below.

Location	Proposed Model Flood Depth	+10% rainfall	+20% rainfall	+30% rainfall
Trapped low point in Pyrmont Street	0.23m	+0.00m	+0.01m	+0.02m
Low point in Light Rail Corridor, Edward Street	0.29m	+0.02m	+0.04m	+0.07m
Low point in Pirrama Road, east of Edward Street	0.38m	+0.01m	+0.03m	+0.05m
Low point in Pirrama Road, NW of Edward Street	0.43m	+0.01m	+0.02m	+0.03m

Table 9. Increase in flood depth with increased rainfall intensity due to climate change

The flood modelling results show that the overall impacts of climate change on flooding at the development site is not significant and does not significantly increase flood risk to the development site. The proposed stormwater mitigation measures provided a much larger reduction in flood level (up to 0.19m lower) than the possible increase in flood level from climate change (up to 0.02m higher for +10% rainfall scenario) .

6 FLOOD PLANNING LEVELS

The flood levels vary around the development site due to the existing varying topography. For non-critical flood areas, (away from the trapped low points in the road network) overland flow for the 100 year ARI flood depths are generally below 70mm and overland flow is contained with the road extents, below kerb height. For the PMF, overland flow is generally less than 200mm within the road network.

For non-critical areas the flood levels around the development site can be taken as 'top of kerb' for the 100 year ARI and 'top of kerb +100mm' for the PMF.

For critical areas, adjacent to the low points in the road network, flood levels around the development site can be taken as the maximum of 'top of kerb' or specific flood level for the 100 year ARI and the maximum of 'top of kerb +100mm' or specific flood level for the PMF (refer to Table 10.)

Critical Flood Areas	100 Year ARI Flood Level	PMF Level
Low point in Pyrmont Street	Max of 6.51m / Top of Kerb	Max of 6.60m / Top of Kerb + 100mm*
Low point in Edward Street	Max of 2.67m / Top of Kerb	Max of 2.89m / Top of Kerb + 100mm*
Low point in Pirrama Road NW of Edward St	Max of 2.63m / Top of Kerb	Max of 2.70m / Top of Kerb + 100mm*
Non-Critical Flood Areas	Top of Kerb	Top of Kerb + 100mm*

Table 10. Flood levels for 100 year ARI and PMF

A Flood Planning Level refers to the permissible minimum building floor levels. For below-ground parking or other forms of below ground development, the Flood Planning Level refers to the minimum level at each access point. Based on the modelled flood levels and the *Interim Floodplain Management Policy* the Flood Planning Levels shown in table 11 apply to the proposed development.

Proposed Development Use	Flood Planning Level
Residential Habitable Floor Level	100 year ARI flood level +0.5m
Residential Non-Habitable Floor Level	100 year ARI flood level
Retail and Business Floor Level	100 year ARI flood level
Below Ground Parking*	100 year ARI flood level +0.5m
Critical Facilities Floor Level	100 year ARI flood level +0.5m
Access to and from critical facility within development site	100 year ARI flood level

Note* The below ground garage/car park level applies to all possible ingress points to the car park such as vehicle entrances and exits, ventilation ducts, windows, light wells, lift shaft openings, risers and stairwells.

Table 11. Flood Planning Levels

Around the development site, the PMF level is lower than the 100 year ARI flood level + 0.5m. To comply with the *Interim Floodplain Management Policy*, the proposed vehicle entrance on Pyrmont Street must be protected against the 100 year ARI flood level + 0.5m. The 100 year ARI flood level at the location of the proposed vehicle entrance varies from 6.62m to 6.94m. Flood protection must therefore be provided to a height 7.44m to comply with the Flood Planning Level. This protection can be achieved with the use of a flood gate across the entrance opening.

7 CONCLUSION

The existing Council flood model shows the potential for significant flooding within low points in the road network around the development site. The existing Council model adopts a conservative pit blockage factor of 100% for sag pits. This approach does not allow any overland flow to enter the below ground pit/pipe system which results in the significant ponding. Pit blockage factors have therefore been amended to comply with *City of Sydney Stormwater Drainage Design Code*. This approach was discussed and confirmed with Council's Water Assets Senior Engineer refer to Appendix C for record of correspondence.. There have been no recorded flooding incidents at the site location.

This flood impact assessment confirms that overland flows occur around the site and are generally contained within the road network. To mitigate flood hazard and flood risk, upgrades are proposed to the existing stormwater pits and pipes as detailed in Appendix B of this report. The proposed mitigation works reduce the 100-year ARI flood depth; reducing flood risk to the development, adjacent properties and the general public. The proposed works will have a positive environmental impact with regards to flood risk.

The flood modelling takes into account the potential impacts from climate change and the stormwater mitigation ensures that the impacts of climate change have no impact on flood risk to the development site or elsewhere.

The proposed development conforms to the following:

- Darling Harbour Catchment Flood Study, BMT WBM, October 2014.
- City of Sydney Interim Floodplain Management Policy, May 2014.
- Sydney Local Environmental Plan 2012.
- Sydney Development Control Plan, December 2013.
- Sydney Streets Technical Specifications, June 2016.
- NSW Floodplain Development Manual, 2005
- NSW Sea Level Rise Policy Statement, 2009
- NSW Floodplain Risk Management Guideline - Practical Consideration of Climate Change, 2007
- SEARS

THE STAR

APPENDICES

8 APPENDIX A – DEVELOPMENT PROPOSALS

MODIFICATION 13 PROPOSED WORKS

New Ritz-Carlton Hotel and Residential Tower

- Demolition of part of the existing building in the northern portion of the site, including part of the Pirrama Road façade and part of the Jones Bay Road façade.
- Construction of a new Tower, 237.0 metres AHD (approximate, 232.9 metres from Pirrama Road);
- Residential uses across 35 levels, comprising:
    - A residential vehicular drop off lobby on Level B2
    - A residential lobby on Level 00 to be accessed from Jones Bay Road;
    - Residential communal space on Level 07 to be accessed via Level 08; and
    - 204 residential apartments located from Levels 05 to 06 and from Levels 08 to 38, featuring one-bedroom, two-bedroom and three-bedroom unit types *(Note – no Level 13)*
- Hotel uses across 31 levels, comprising:
    - A hotel arrival lobby on Level B2 to be accessed from the new Ritz-Carlton porte-cochere along Pirrama Road;
    - A hotel Sky Lobby for guest check-in on Level 39 and 40, featuring a restaurant, bar and lounge;
    - 220 hotel rooms located from Level 42 to 58 and from Level 60 to 61
    - A hotel spa and gym on Level 07
    - A VIP link to the Sovereign Room on Level 04 and 04 Mezzanine
    - A Ritz-Carlton Club lounge and terrace on Level 59
    - Hotel staff end-of-trip facilities on Level B3
    - Hotel staff arrival point on Level 00
    - Hotel back-of-house and plant on Level 03, 05 and 41
- A Neighbourhood Centre consisting of a cafe, library, learning / innovation hub and function centre;
- A new car-parking stacker system below the new porte-cochere of the Ritz-Carlton Hotel, with a total capacity of 220 spaces, to serve the new hotel and apartments; and
- A new drop-off / pick up area (short-term parking) on Jones Bay Road for the proposed apartments.

Level 07

- A 'Ribbon' at Level 07 connecting the new Hotel and Residential Tower to the existing building along Pirrama Road, comprising:
    - Two pools and associated pool decks (one for the new Hotel, one for The Star); and
    - Two food and beverage premises with associated store rooms and facilities;
- Lift access from the Level 05 Terrace to Level 07;
- Residential communal open space associated with the new residential apartments, comprising pool and landscaped terrace at the base of the Tower adjacent to Jones Bay Road;
- Gym and associated change rooms and facilities for the residents;
- Gym and associated change rooms and facilities for hotel guests; and
- Landscaping treatments.

Level 05 Terrace

- Three food and beverage outlets with external areas;
- Completion of the Vertical Transportation drum to connect with Level 05 Terrace;
- Designated event spaces on the Terrace; and
- Landscaping treatment.

Level 05 Astral Hotel and Residences Recreational Facility Upgrade

- New pool deck, pool, spa, gym and amenities upgrade for Astral Hotel and Residences.

Level 04 Mezzanine / 04 / 03 Tower to Sovereign Link by Escalator and Lift

- Link from the Tower to the Sovereign Resort along the Level 04 Mezzanine, down by escalators to Level 04, and then down by lift to Level 03; and
- Extension of the latter lift above to service Level 00, 01, 03, 04 and 05.

Level 03 Sovereign Column Façade Treatment along Pirrama Road

- New glazed detail to enclose exposed Level 03 Sovereign columns along the Pirrama Road façade.

Façade Integration Works

- Upgrades to the Pirrama Road and Jones Bay Road façades to integrate the new Ritz Carlton Hotel and Residential Tower with the existing building.

Infrastructure Upgrades

- A new plant room located within the podium over Levels 03, 04, 05 and 06 of the proposed Hotel and Residential Tower;
- Relocation of the current Level 03 cooling towers (adjacent to the MUEF) to the Level 09 plant room above the Level 06 plantroom adjacent to the Astral Hotel;
- New capstone microturbine units and associated flues in the proposed plant room at Level 03 between the Darling Hotel and the Astral Residence Tower;
- New capstone microturbine units and associated flues in the new Level 03 plant room at the base of the Tower;
- Relocation of the existing main switch-room to the new plant room on Level 02, south of the demolition area;
- Relocation of the existing data recovery centre to the new plant room on Level B1 of the Darling Hotel;
- Relocation of diesel generator flues to the side of the new Level 09 plantroom, adjacent to Astral Hotel

Level B2 Transport Interchange

- Upgrades to the Event Centre Loading Dock;
- Entry into Basement car stacker for the Tower apartments and Ritz-Carlton Hotel;
- New commuter bike parking and hire bike system;
- Upgrade of finishes to light rail station surrounds and removal of existing wall barrier to the Pirrama Road frontage;
- Upgraded taxi-rank arrangements;
- New Star coach parking; and
- Realignment of kerbs and line-marking.
- Note – no works to the Light Rail corridor

Transport Improvements – Other Locations

- Reconfiguration of existing median strips on Jones Bay Road and addition of new median strip on Pyrmont Street, with associated line-marking to enable a new right-hand turning lane into the Astral Hotel Porte-Cochere;
- New Pyrmont Street carpark entry and exit, associated line marking, changes to internal circulation, and reconstruction of the pedestrian footpath along Pyrmont Street; and
- Relocation of existing feeder taxi-rank from Jones Bay Road to the Level B2 transport interchange.

Site Wide Landscape and Public Domain Upgrades

- Upgrades to street frontages along Pirrama Road (for the Hotel Porte Cochere) and Jones Bay Road (for the residential entry);
- Upgrades to street frontage to Pyrmont Street, due to new car parking entry; and
- Entrance upgrade to the SELS building at the corner of Jones Bay Road and Pyrmont Street.

Level 00 - Restaurant Street

- Creation of a new destination Restaurant Street by:
    - Incorporating existing Food and Beverage premises on Level 00; and
    - Converting existing retail shops into new Food and Beverage tenancies, including the new Century tenancy at the Jones Bay Road end.

Pirrama Road and Jones Bay Road Food and Beverage

- A revised food and beverage tenancy at the existing Pizzaperta outlet along Pirrama Road;
- A new tenancy at the Marquee street entry; and
- A small café outlet adjacent to the residential lift lobby at Jones Bay Road.

Food and Beverage – Other Locations

- Reconfiguration of Harvest Buffet, including new escalators from Level 00 Food Court to Level 01; and
- Refurbishment of Bistro 88 into the interim Century tenancy

Darling Hotel Corners

- Upgrade of the corner plaza at the Union/Edward Street property entry:
    - A new Food and Beverage premises on Level 01 and 02;
    - A new entry foyer leading to the Food Court;
    - A relocated awning enclosure at street level;
- Upgrade of the corner plaza at the Union/Pyrmont Street property entry:
    - A new awning enclosure at for the existing café;
    - Eight (8) luxury display cases at Darling Hotel car park entry; and
    - Two car display areas at Darling Hotel car park entry.

Site-Wide Acoustic Strategy

- A site-wide acoustic monitoring strategy applied to assess impact of potential noise generating sources in Mod13.

Site-Wide Lighting Strategy

- A site-wide lighting strategy integrating and improving the existing lighting across the precinct, with new lighting the proposed Tower, Podium and Ribbon, including:
    - Internal lighting of Hotel and Residential spaces;
    - Illuminated highlights at the Sky Lobby and Club Lounge levels;
    - Integrated lighting on the eastern and western vertical façade slots and angled roof profile;
    - Podium external illumination from awnings, and under retail and lobby colonnades;
    - Landscape lighting on Level 07 open terraces and pool decks;
    - Feature lighting accentuating the wing-like profile of the Ribbon and vertical element;
    - Internal and external lighting to Food and Beverage outlet at Union/Edward Street corner;
    - Façade LED lighting to the heritage SELS Building

Special Lighting Events

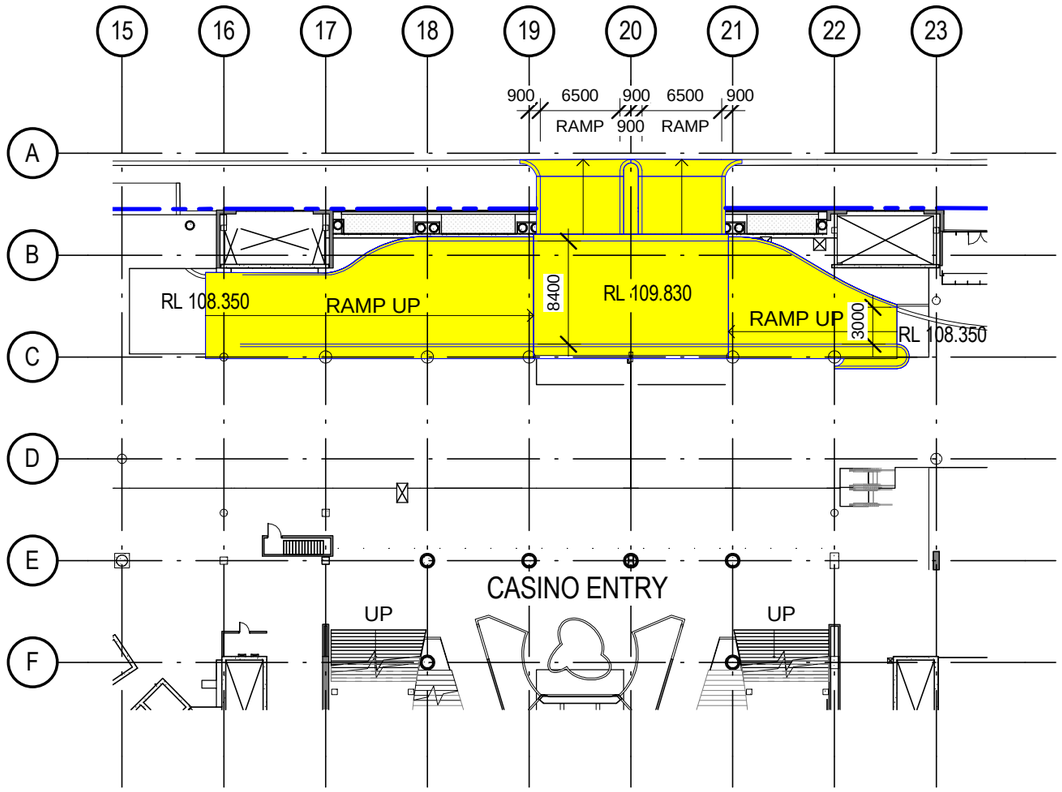
- Approval for fifty three (53) special Lighting Events per year for the use of permanent installation of moving projector lights on the rooftop of the Astra hotel

Signage Upgrades

- Consolidation of existing signage approvals and new signage, including:
    - Building identification;
    - Business identification (including Food and Beverage premises); and
    - Signage on the Tower and Podium.

Stormwater upgrades

- Stormwater upgrade works, including increased pit inlets and pipe capacities at the low points along Pyrmont Street and Edward Street to decrease the potential flood risk to the site, adjacent existing properties and public domain compared to the existing situation.



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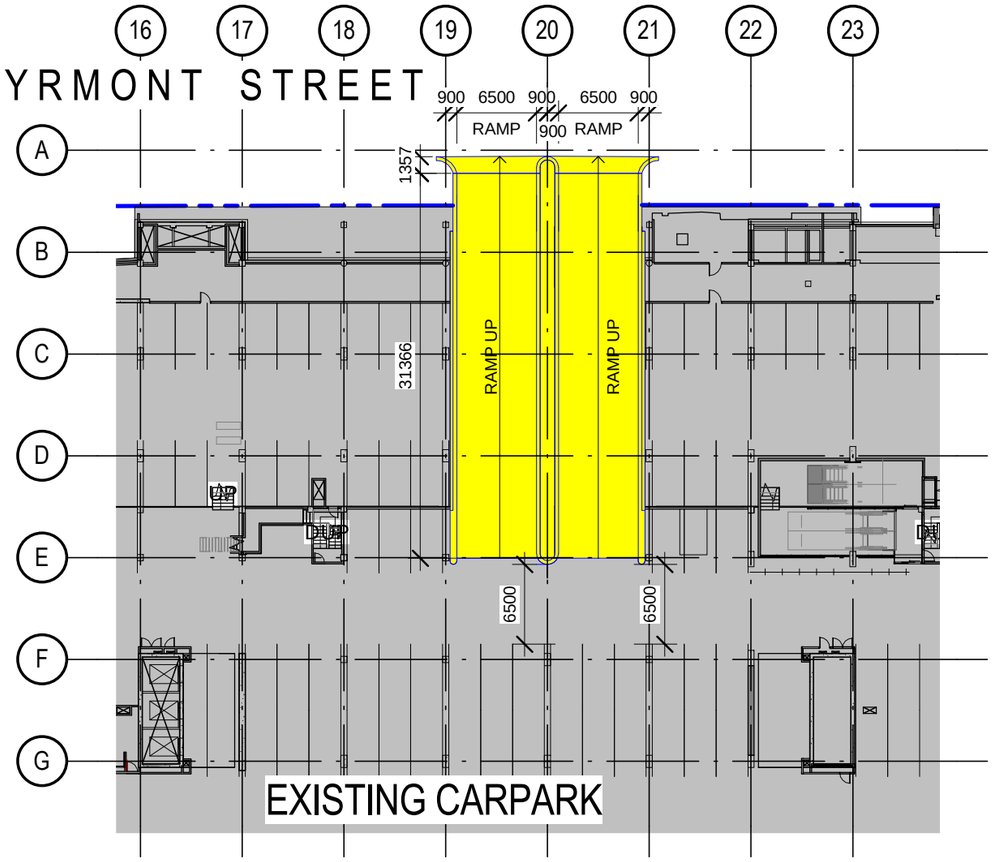

2 A4010 PROPOSED SITE PLAN - LEVEL B1

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Issue

Issue Description Date Chk Auth

dwp suters

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THE STAR - MODIFICATION 13

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80 PYRMONT STREET
PYRMONT NSW 2009

Client
THE STAR ENTERTAINMENT GROUP

Drawing
PROPOSED CARPARK ENTRY PLANS - PYRMONT ST

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Project No.
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Drawing No.
SK1309

Issue

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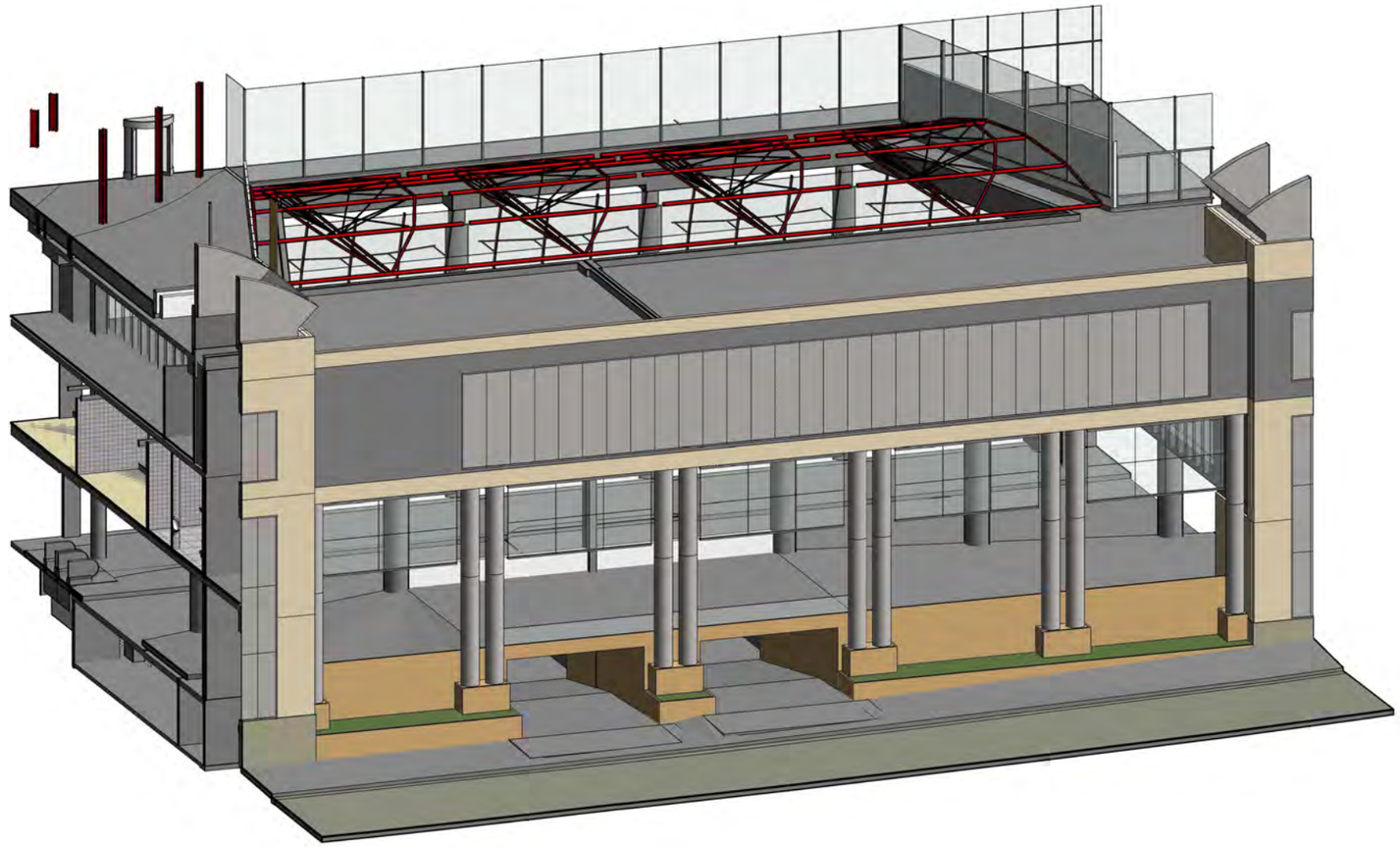

PROPOSED

Issue

Issue	Description	Date	Chk	Auth

dwp suters

Project
THE STAR - MODIFICATION 13

Location
80 PYRMONT STREET
PYRMONT NSW 2009

Client
THE STAR ENTERTAINMENT GROUP

Drawing
PROPOSED CARPARK ENTRY IMAGES - PYRMONT ST

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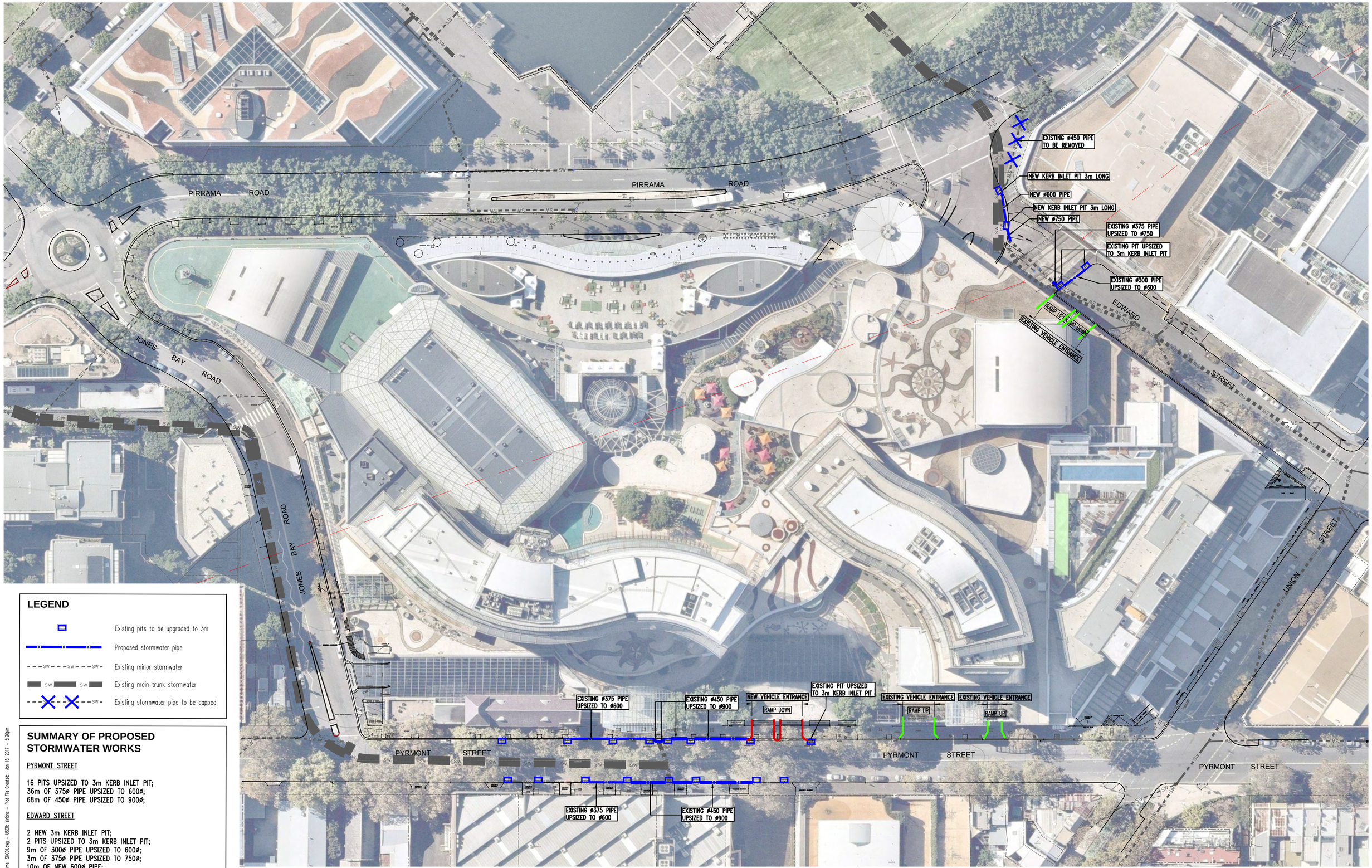
9 APPENDIX B – PROPOSED STORMWATER WORKS



LEGEND

- Existing pits to be upgraded to 3m
- Proposed stormwater pipe
- Existing minor stormwater
- Existing main trunk stormwater
- Existing stormwater pipe to be capped

SUMMARY OF PROPOSED STORMWATER WORKS

PYRMONT STREET

16 PITS UPSIZED TO 3m KERB INLET PIT;
36m OF 375ø PIPE UPSIZED TO 600ø;
68m OF 450ø PIPE UPSIZED TO 900ø;

EDWARD STREET

2 NEW 3m KERB INLET PIT;
2 PITS UPSIZED TO 3m KERB INLET PIT;
9m OF 300ø PIPE UPSIZED TO 600ø;
3m OF 375ø PIPE UPSIZED TO 750ø;
10m OF NEW 600ø PIPE;
5m OF NEW 750ø PIPE.

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A1 0 1 2 3 4 5 6 7 8 9 10

PRELIMINARY

Rev	Description	Eng	Draft	Date
P1	ISSUE FOR INFORMATION	EC	WW	???

Architect
ARCHITECTS NAME
ARCHITECTS ADDRESS

Civil Engineer
Taylor Thomson Whitting
612 9439 7288 | 48 Chandos Street St Leonards NSW 2065

Project
STAR ENTERTAINMENT

Sheet Subject
PROPOSED STORMWATER WORKS

Scale : A1	Drawn	Authorised
1:500	WW	SB

Job No	Drawing No	Revision
161718	SKC01	P1

Plot File Created: Jan 16, 2017 - 5:26pm

10 APPENDIX C – RECORD OF CORRESPONDENCE

Taylor Thomson Whitting

Structural
Civil
Traffic
Facade

20 March 2017

161718

The Star – Record of Telephone Conversation

Conversation with:
Shah Alam
Senior Engineer – Water Assets
City Of Sydney, City Infrastructure
0292 885 925

This Record of Telephone Conversation confirms the discussion regarding The Star development, Pyrmont, and the blockage factor that should be applied for the stormwater upgrades associated with the development. The telephone conversation was made at 2.00pm on 20 March 2017.

The following description to Shah was made of the existing flood characteristic and the impact the pit blockage factors:

The existing flood characteristics were explained around The Star site. The existing Darling Harbour flood model results were explained that show significant flood depth in Pyrmont Street, primarily caused by conservative pit blockage factors of 100% used for all sag pits. It was explained that this assumes that no surface water runoff is able to flow into the storm water system at low points, regardless of the capacity of the pit inlet or pipes. It was also explained that The Darling Harbour flood study also confirms that there is no recorded historical flooding at the development site (from newspaper articles and Sydney Water records).

Shah was asked whether the pit blockage factors as stated in the Sydney Streets Technical Manual should be used for designing the proposed stormwater upgrades, instead of those adopted in the Darling Harbour Flood Study.

Shah confirmed that the pit blockage factors within the Sydney Streets Technical Manual should be used where known pit sizes and/or new pits are to be designed.

A follow up email correspondence was sent to Shah to confirm the telephone conversation, but no response was made.

From: Eirian Crabbe Sent: Mon 20/03/2017 3:31 PM
To: SAlam@cityofsydney.nsw.gov.au
Cc:
Subject: RE: Pit Blockage Factors

Hi Shah,

Many thanks for the telephone conversation. Just to confirm our discussion: for the design and modelling of new pits the flood model must use the pit blockage factors in the *Sydney Street Technical Standards: A4 Stormwater Drainage.*

Regards

Eirian

From: Eirian Crabbe
Sent: Friday, 17 March 2017 12:02 PM
To: 'SAlam@cityofsydney.nsw.gov.au'
Subject: RE: Pit Blockage Factors

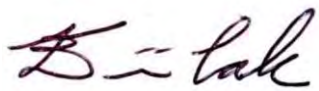
Hi Shah,

Just a quick query, I no longer require a response to the queries below. Please can you confirm if the pit blockage factors within the City of *Sydney Sydney Street Technical Standards: A4 Stormwater Drainage* should be applied to new pits within a site-specific development flood model?

Many thanks

Eirian Crabbe

Prepared by:
TAYLOR THOMSON WHITTING (NSW) PTY LTD



EIRIAN CRABBE
Senior Civil Engineer

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